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(54) WEAR RESISTANT ALLOY, AND CONTROL ROD DRIVE DEVICE AND NUCLEAR REACTOR USING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To improve wear resistance as well as corrosion resistance and impact resistance by specifying respective quantities of C and Cr in an Fe-base or Ni-base alloy for control rod drive device and controlling the amount of chromium carbide precipitated and the amount of Cr in a matrix, respectively.
SOLUTION: C and Cr are incorporated by 1.0-3.0% and 12-50% by weight ratio, respectively, into the composition of a wear resistant alloy composed of Fe- or Ni-base alloy. Moreover, rod-like chromium carbide is incorporated, and the amount of chromium carbide is regulated to 10-28.5% by area ratio and in amount of chromium carbide, remaining in matrix, of ≥10% is secured. Further, the Vickers hardness of this matrix at room temp. is regulated to 230-260. If necessary, 0.1-1.5%, in total, of either or both of Ti and Nb are incorporated into the alloy composition. By using this wear resistant alloy, the smooth drive of a nuclear reactor control rod can be ensured over a long period in high temp. water under high load. Moreover, because this alloy is free from cobalt, exposure dose can be reduced and the safety of a nuclear power plant can be increased.

CLAIMS

[Claim(s)]

[Claim 1]A wear resistant alloy which has cylindrical chromium carbide and to which the amount of chromium carbide is characterized by a chromium amount of 10 to 28.5% and a base consisting of 10% of the weight or more of a Fe group or a Ni group alloy according to an area rate by weight including C1.0-3.0% and 12 to 50% of Cr.
[Claim 2]A wear resistant alloy which has cylindrical chromium carbide and to which the amount of chromium carbide is characterized by consisting of a Fe group or a Ni group alloy whose Vickers hardness of a room temperature of 15 to 28.5% and a base is 230-260 according to an area rate by weight including C1.0-3.0% and 12 to 50% of Cr.
[Claim 3]A wear resistant alloy which has cylindrical chromium carbide C1.0-3.0% including 12 to 50% of Cr, and 0.1 to 4.0% of aluminum and in which a chromium amount of a base is characterized by consisting of a Fe group or a Ni group alloy whose Vickers hardness of a room temperature of 10 % of the weight or more and a base is 200-350 by weight.
[Claim 4]By weight, one or more sorts of 12 to 50% of Cr, and Ti and Nb are included, and 0.1 to 1.5% is included in total C1.0-3.0%. A wear resistant alloy which has cylindrical chromium carbide and in which a chromium amount of a base is characterized by Vickers hardness of a room temperature of 10 % of the weight or more and a base consisting of a Fe group or a Ni group alloy which is 200-380.
[Claim 5]By weight, one or more sorts of 12 to 50% of Cr, and Mo and W are included, and 0.1 to 10% is included in total C1.0-3.0%, A wear resistant alloy which has cylindrical chromium carbide and in which a chromium amount of a base is characterized by Vickers hardness of a room temperature of 10 % of the weight or more and a base consisting of a Fe group or a Ni group alloy which is 200-400.
[Claim 6]A wear resistant alloy characterized by quantity of secondary carbide being 5% or less in surface ratio in either of claims 1-5.
[Claim 7]Housing.
A hollow piston provided in this housing.
A driving piston which drives this hollow piston up and down.
A roller formed in this tube between said hollow piston and a tube in said housing.
A pin used as the axis of rotation of this roller.
It is the control rod drive provided with the above, and said roller is constituted by the alloy according to any one of claims 1 to 6.

[Claim 8]Housing.
A hollow piston provided in this housing.
A driving piston which drives this hollow piston up and down.
A roller formed in this tube between said hollow piston and a tube in said housing.
A pin used as the axis of rotation of this roller.
Are the control rod drive provided with the above, and said roller and a pin under 1 kg per sliding width of 0.75 mm of this roller and a pin of load, Abrasion loss of said roller in inside of 288 ** high temperature hot water and both of a pin is constituted by an iron group or a nickel base casting alloy of 10 mg [per km of sliding distance] or less to sliding width of 7.5 mm.

[Claim 9]Housing.
A hollow piston provided in this housing.
A driving piston which drives this hollow piston up and down.
A roller formed in this tube between said hollow piston and a tube in said housing.
A pin used as the axis of rotation of this roller.
It is the control rod drive provided with the above, and, as for said roller, abrasion loss in inside of 288 ** high temperature hot water consists of an iron group or a nickel base casting alloy which is 8.5 mg or less per km of sliding distance to sliding width of 7.5 mm under 1 kg per slidin width of 0.75 mm with said pin of load.

[Claim 10]Housing.
A hollow piston provided in this housing.

A driving piston which drives this hollow piston up and down.
A roller formed in this tube between said hollow piston and a tube in said housing.
A pin used as the axis of rotation of this roller.
It is the control rod drive provided with the above, and, as for said pin, abrasion loss in inside of 288 ** high temperature hot water consists of an iron group or a nickel base casting alloy which is 4.5 mg or less per km of sliding distance to sliding width of 7.5 mm under 1 kg per sliding width of 0.75 mm with said roller of load.

[Claim 11]A pressure vessel.
A fuel assembly provided in this pressure vessel.
A control rod formed between these fuel assemblies.
The control rod drive according to any one of claims 7 to 10 which drives this control rod.
It is the nuclear reactor provided with the above, and this nuclear reactor is 45 or more GWd/t in a burnup, Bent volume per burnup 8 GWd/t is [bent volume in 0.8 mm or less and said burnup 45 GWd/t of a channel box of an outermost periphery for which said fuel assembly is constituted] 2.8 mm or less, Said control rod drive could use it by no exchanging for 30 years or more, and made an operating ratio not less than 85%.

[Claim 12]A roller for control rod drives consisting of the wear resistant alloy according to any one of claims 1 to 6.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the suitable wear resistant alloy for the slide member which starts the wear resistant alloy which was simultaneously [with abrasion resistance] excellent in corrosion resistance and shock resistance, especially is used for the control rod drive of a nuclear reactor plant, and the control rod drive and nuclear reactor using it.
[0002]
[Description of the Prior Art]Many cobalt base alloys are conventionally used for the sliding part in a nuclear power plant. For example, the casting material of Stellite is used for the roller for a guide and bush of the control rod. This Stellite uses cobalt as the main ingredients, and containing chromium, it contains a small amount of tungsten, iron, and nickel for carbon further 1 to 2.5% 28 to 30%. Since it is high chromium, corrosion resistance is good, and since it is high carbon, hardness is highly excellent in abrasion resistance. However, cobalt is eluted [in / in thi alloy member / the nuclear reactor underwater of high temperature high pressure] in furnace water, and this adheres to the fuel cladding tube surface, and is radioactivated, and it is eluted again, and circulates through the inside of furnace water. As a result, a plant periodic inspection

ınd the dose of radioactivity at the time of repair increase, off-periods of operation delays, and :he operating ratio of a plant is reduced. There is the necessity of applying the sliding material-›roof replaced for preventing increase of the dose by elution of such cobalt at a cobalt base ılloy. As the roller which does not use cobalt as a constituent element, and an abrasion ·esistance material for bushes, JP,59-52228,B is already indicated. Although this uses a nickel ›ase alloy for roller material, since abrasion resistance is less than a cobalt base alloy, by the ıigh sliding part of mechanical load, the dimensional change by wear becomes large and it cannot ›ear prolonged use. Although the nickel base alloy which added chromium and niobium was ndicated by JP,58-23454,B, compared with Stellite, an impact resistance value is low and the ·eliability over the impact load at the time of scrum had a difficulty.

[0003]

[Problem(s) to be Solved by the Invention]In order that the purpose of this invention may guarantee the smooth drive of a reactor control rod over a long period of time in high temperature hot water and under high load. Abrasion resistance is superior to Stellite, and also to the impact load by the high speed drive at the time of scrum, it is reliable, and there is no elution of cobalt, and it is in providing the wear resistant alloy which can reduce a dose of radioactivity and can improve the safety of a nuclear power plant, and the control rod drive and nuclear reactor using it.

[0004]

[Means for Solving the Problem]This invention is weight, including C1.0-3.0% and 12 to 50% of Cr, it has cylindrical chromium carbide and the amount of chromium carbide is in a wear-resistant alloy, wherein a chromium amount of 10 to 28.5% and a base consists of 10% of the weight or more of a Fe group or a Ni group alloy by an area rate.

[0005]This invention is weight and contains C1.0-3.0% and 12 to 50% of Cr, It has cylindrical chromium carbide and the amount of chromium carbide is in a wear-resistant alloy, wherein Vickers hardness of a room temperature of 15 to 28.5% and a base consists of a Fe group or a Ni group alloy which is 230-260 by an area rate.

[0006]This invention is weight and contains 12 to 50% of Cr, and 0.1 to 4.0% of aluminum C1.0-3.0%, It has cylindrical chromium carbide and a chromium amount of a base is in a wear resistant alloy, wherein Vickers hardness of a room temperature of 10 % of the weight or more and a base consists of a Fe group or a Ni group alloy which is 200-350.

[0007]This invention is weight and contains 0.1 to 1.5% for one or more sorts of 12 to 50% of Cr, and Ti and Nb in total C1.0-3.0%, It has cylindrical chromium carbide and a chromium amount of a base is in a wear resistant alloy, wherein Vickers hardness of a room temperature of 10 % of the weight or more and a base consists of a Fe group or a Ni group alloy which is 200-380.

[0008]This invention is weight and contains 0.5 to 10% for one or more sorts of 12 to 50% of Cr, and Mo and W in total C1.0-3.0%, It has cylindrical chromium carbide and a chromium amount of a base is in a wear resistant alloy, wherein Vickers hardness of a room temperature of 10 % of the weight or more and a base consists of a Fe group or a Ni group alloy which is 200-400.

[0009]This invention is characterized by quantity of secondary carbide being 5% or less in surface ratio.

[0010]It is the control rod drive provided with the following, and said roller is constituted by the above-mentioned alloy.

Housing.

A hollow piston provided in this housing.

A driving piston which drives this hollow piston up and down.

A roller formed in this tube between said hollow piston and a tube in said housing.

A pin used as the axis of rotation of this roller.

[0011]A control rod drive of this invention said roller and a pin under 1 kg per sliding width of 0.75 mm of this roller and a pin of load, Abrasion loss of said roller in inside of 288 ** high temperature hot water and both of a pin is constituted by an iron group or a nickel base casting alloy of 10 mg [per km of sliding distance] or less to sliding width of 7.5 mm.

[0012]As for a control rod drive of this invention, said roller consists of an iron group or a nickel

base casting alloy whose abrasion loss in inside of 288 ** high temperature hot water is 8.5 mg or less per km of sliding distance to sliding width of 7.5 mm under 1 kg per sliding width of 0.75 mm with said pin of load.

[0013]In a control rod drive of this invention, as for said pin, abrasion loss in inside of 288 ** high temperature hot water consists of an iron group or a nickel base casting alloy which is 4.5 mg or less per km of sliding distance to sliding width of 7.5 mm under 1 kg per sliding width of 0.75 mm with said roller of load.

[0014]A fuel assembly in which this invention was provided in a pressure vessel and this pressure vessel, and a control rod formed between these fuel assemblies, It is the nuclear reactor provided with the above-mentioned control rod drive which drives this control rod, This nuclear reactor is 45 or more GWd/t in a burnup, and bent volume per the burnup 8 GWd/t is [bent volume in 0.8 mm or less and said burnup 45 GWd/t of a channel box of an outermost periphery which constitutes said fuel assembly] 2.8 mm or less, Said control rod drive could use it by no exchanging for 30 years or more, and made an operating ratio not less than 85%.

[0015]This invention is on a roller for control rod drives consisting of the above-mentioned wear resistant alloy.

[0016]A control rod drive of a nuclear power plant is changing from a thing to a thing new type ir which a slight movement drive by an electric motor is possible of the conventional water pressure drive type. In a control rod drive of this new type, in order to make a motion of a hollov piston smooth, a guide idler is used, but compared with the conventional roller for control rods, load load is extraordinarily large, and higher abrasion resistance is required. From a high speed drive of a piston in an emergency, high reliability over breakage by impact load is required.

[0017]In this roller, wear is produced mainly on roller inner skin and the surface of a lock-pin which supports a roller. In this case, wear is-less lubricous wear in high temperature hot water, and turns into a roller and adhesive wear by relative sliding motion of a pin. In this adhesive wea big shearing stress occurs by agglutination in a contact portion, and damage to a sliding surface arises. In this case, although partial destruction arises without hardly being accompanied by plastic deformation and it becomes worn powder with material with it, with material which has ductility, a plastic flow layer is formed, by receiving repetition sliding, a part of plastic flow layer carries out a separation fracture, and it serves as worn powder. [scarce ductility and] [hard] It is necessary to make a base to some extent soft from a shock-proof viewpoint at the time of a high speed drive of the above-mentioned roller, and to give ductility. Therefore, in order to improve the abrasion resistance of roller material excellent in shock resistance, it is important t make a separation fracture hard to control growth of a plastic flow layer after it decreases frequency of agglutination first and agglutination arises, to strengthen the plastic flow layer itsel further, and to produce. However, consideration was not carried out [as opposed to / especially / strengthening of this plastic flow layer] in a charge of a conventional material, but abrasion resistance in inside of high temperature hot water had a limit.

[0018]Since long term use of the guide idler in a control rod drive mechanism is carried out in high temperature hot water, it also needs to have sufficient corrosion resistance which can bea it.

[0019]This invention is made in consideration of these things. That is, it is that the most important point of this invention distributes first chromium carbide whose shape is comparativel big in a soft substrate to bulk materials, such as a roller and a bush. In this case, carbide supports load concerning a wearing surface, and decreases in number frequency of agglutinatior with a mating material, and has an effect which controls growth of a plastic flow layer. That is, since a plastic flow layer will be disrupted on carbide and will not be thoroughly covered to becoming easy to produce agglutination since the surface of carbide will be thoroughly covered with surface plastic flow with an alloy if carbide is small if carbide is large to some extent, generating of agglutination can be controlled. It is required for size of carbide to be above large to some extent for that purpose. Abrasion resistance which was excellent in an alloy of this invention when the sum of the length of length and width was 50 microns or more was shown. Another reason for enlarging size of chromium carbide to some extent is control of a plastic flo layer by an anchor effect. If it becomes 20 microns or less, an anchor effect by carbide will

decrease, in a plastic flow layer, ****** and capacity which carries out peel off break at once will become is easy to be formed greatly, and abrasion loss will also become large. Quantity of chromium carbide is also important requirements in this invention. That is, depressor effect [as opposed to / in quantity of chromium carbide /% / 10 / or less / agglutination and plastic flow at surface ratio] is not enough. If it becomes not less than 25%, abrasion loss of a pin which is a mating material increases, and it is not desirable as the whole. A further shock-proof fall also becomes remarkable. It is necessary to make quantity of chromium carbide into 10 to 25% by surface ratio that it is compatible in good abrasion resistance and shock resistance.

[0020]What is necessary is just to make it crystallize directly from the liquid phase as primary phase carbide or eutectic carbide with nickel by a solidifying process to obtain such big and rough chromium carbide. It is necessary to adjust a carbon content in nickel which contains chromium for that purpose to an appropriate range. Preferably, 1.5%, since it would become not less than 25% if surface ratio of chromium carbide will be 10% or less and it becomes above 2.5% preferably not less than 3.0%, below, 1.0% or less of a carbon content made 1.5 to 2.5% into a proper range.

[0021]It is in furthermore an important operation of big and rough chromium carbide in this invention forming a surface layer which surface carbide was finely ground by shearing stress, it was incorporated by plastic flow into a substrate, and detailed chromium carbide distributed densely, and is different from a substrate of a basis. Such a surface layer has intensity and high hardness, and since it is formed so that a portion which damage produced may be buried, what is called self-compensation is revealed. Thus, it needs to be important that hardness of a substrate part is moderately soft for chromium carbide ground finely being incorporated into a substrate part, without being discharged out of a system, and it needs to be 400 or less by less than Vickers hardness number (Hv)350 and alloy composition. In hardness beyond this, it becomes what is called ABURESSHIBU wear that chromium carbide is not enough embedded into a plastic flow layer, but depends for stopping at the wear surface in part and scratching, and damage to ** material and a mating material becomes large, and a fall of an impact resistance value becomes remarkable. The hardness of a substrate part needs to restrict a precipitation amount of secondary carbide which deposits by the cooling middle below a solution treatment temperature of carbide, or heat treatment to 2% or less by surface ratio, in order to change a lot and to be referred to as 350 or less Hv with secondary carbide. A lower limit of hardness was the hardness of nickel and an iron substrate which dissolved chromium, set an appropriate range to Hv 200-400, and was taken as a proper range with alloy composition.

[0022]Hardness of a chromium carbide phase is important from a viewpoint of making damage to a mating material as small as possible. That is, if other carbide formation elements exist, chromium carbide makes remarkable ABURESSHIBU wear which depends it by dissolving and hardness becoming high for a mating material to scratch, and is not preferred as the whole. When especially chromium carbide whose hardness of carbide is Hv 1300-1800 according to the wear test result using material which distributed carbide which has various hardness with a powder sintering process was set to that there is little abrasion loss of a mating material, and 2000 or more Hv(s), it turned out that abrasion loss of a mating material increases quickly.

[0023]It is necessary to make preferably into not less than 12% a chromium amount of a base which dissolved in nickel or an iron substrate 10% of the weight or more from a viewpoint of securing corrosion resistance over high temperature hot water. Less than this is not enough as corrosion resistance in inside of high temperature hot water, and if it becomes not less than 25 preferably not less than 35%, since toughness will fall on the contrary, 12 to 25% is proper. Chromium reacts to carbon at the time of coagulation, and since it becomes chromium carbide and is consumed, it is necessary to add many chromium further in proportion to a carbon content as alloy composition at the time of the dissolution, and to secure a chromium amount which stops at a base. That is, 12+8xC to 25+8xC % is required as a total chromium amount.

[0024]An alloy of this invention has a viewpoint of corrosion-resistant improvement to still more effective addition of molybdenum, tungsten, niobium, or titanium, although abrasion resistance which fully exceeds Stellite by three fundamental ingredients shown above is obtained. Although molybdenum and tungsten dissolve mainly in a substrate and improve corrosion resistance, if

0.5% of the effect does not exist below and it exceeds 10%, in hardness, 2000 or more-Hv hard carbide will deposit not less than 2%, an impact property will fall, and abrasion loss of a mating material increases and they are not preferred. 1 to 5% is preferred. It is effective for fixing free carbon which is dissolving in a substrate and improving corrosion resistance, and niobium carbide hard at more than it deposits in the range with suitable 0.1 to 1.5%, and addition of niobium or titanium causes a fall of an impact resistance value, and it increases abrasion loss of a mating material. 0.1 to 0.5% is preferred.

[0025]Since corrosion resistance over high temperature hot water was secured while a hard phase which broke finely about a substrate phase was required for sufficient softness to be embedded, it has the hardness of Hv 200-400, and nickel or an iron group alloy which dissolved chromium was chosen. 12% or less of a chromium amount was not enough as corrosion resistance in inside of high temperature hot water, since toughness fell on the contrary when it became not less than 50%, it was made into 12 to 50%, and it was preferably made into 15 to 30%. In particular, 20 to 25% is preferred.

[0026]Although it is indispensable to strengthening a base and forming chromium carbide, 1.2%, its abrasion resistance is low, and since C will increase wear of a mating material if 3.0% is exceeded, it is not preferred [C] below. 1.5 to 2.5% is more preferred.

[0027]It is added by deoxidizer at the time of manufacturing after alloy powder, etc., and 1% or less of Si is desirable. In particular, 0.05 to 0.5% is preferred.

[0028]Mn is the same as that of Si, is desirable, is more desirable, and can be made additive-free from on manufacture like Si. [0.1 to 0.5% of] [2% or less of]

[0029]aluminum is added 0.1 to 4.0%, in order to carry out strengthening of oxidation resistance and a base. In particular, addition to a Ni group alloy is preferred.

[0030]In order to use nickel as austenitic stainless steel to a Fe group alloy, it is added 8 to 20%. 8 to 13% is especially preferred.

[0031]Zr group alloy which has the following presentations to 45 or more GWd/t of extraction average burnups as a covering pipe concerning this invention, a spacer, and a channel box is preferred. However, although similarly used for a water rod, a zircaloy-2 alloy can be used.

[0032]Since a prominent effect beyond it is not not only acquired, but Sn lowers processability even if corrosion resistance sufficient at 1% or less and intensity are not obtained and it exceeds 2% conversely, it may be 1 to 2%. In particular, 1.2 to 1.7% is preferred.

[0033]Although Fe is above required 0.02% to improve corrosion resistance and waterproof matter absorptivity, since there is no prominent effect beyond it and processability is lowered even if it adds exceeding 0.55% conversely, it carries out the following 0.55%. In particular, 0.22 to 0.30% is preferred.

[0034]Although nickel improves corrosion resistance notably in a minute amount, it contains above 0.03%, but since hydrogen absorption is promoted conversely and embrittlement is caused it may be 0.16% or less. 0.05 to 0.10% is especially preferred.

[0035]Zr group alloy of this invention can contain 0.05 to 0.15% for Cr. Although Cr is above required 0.05% to raise corrosion resistance and intensity, since processability will be lowered if 0.15% is exceeded conversely, it may be 0.05 to 0.15%.

[0036]To Zr group alloy used for a fuel assembly concerning this invention, zircaloy-2 (1.2 to 1.7% of tin, 0.07 to 0.20% of iron, 0.05 to 0.15% of chromium, 0.03 to 0.08% of nickel, and the remainder are zirconiums substantially), or the zircaloy 4. 1.2 to 1.7% of (tin, 0.18 to 0.24% of iron and nickel0.007% The following and the remainder have zirconium) substantially, and these combine with the above-mentioned alloy and are used according to a thing of 45 or less GWd/t of extraction average burnups.

[0037]As for a covering pipe concerning this invention, it is preferred to be manufactured by performing processing quenched from alpha+ parent phase or a parent phase temperature requirement of a zirconium group alloy after the last hot working, and repeating cold work and annealing processing after that. Subsequent cold-forming nature of especially quenching from alpha+ parent phase temperature is preferred from a high thing as compared with that by which parent phase quenching was carried out.

[0038]As for an alloy, what performed quenching from an above-mentioned parent phase or

alpha+ parent phase is preferred, as for the processing, it is preferred to give before cold forming after plastic working between heat of the last last, and it is good to give especially before the first cold forming.

[0039]It is more preferred than temperature to which alpha+ parent phase exceeds 790-950 **, and alpha phase exceeds 950 ** to consider it as 1100 ** or less, and quenching with a stream, spraying water, etc. is more preferred than such temperature. While it is good to carry out before the first cold forming especially and it pours water in an element tube in that case, a method of heating locally by high frequency induction heating is more preferred than a periphery.

[0040]As a result, the tube interior side is not hardened, but ductility is high, the outside surface side is hardened, corrosion resistance is high and also what has a high rate of hydrogen absorption is obtained. As for heating by alpha+ parent phase, it is preferred that the amount of formation of a parent phase changes alpha phase with temperature, and a parent phase chooses temperature mainly formed. Even if it quenches alpha phase, it does not change, but its ductility with low hardness is high, a needlelike phase with high hardness is formed and quenching from a portion which changed to a parent phase has low cold work nature. however, alpha phase — slightly — also coming out — by being intermingled, high cold-forming nature is obtained and what has low corrosion resistance and a rate of hydrogen absorption is obtained. It heats at temperature which becomes an area rate of 80% - 95% as a parent phase, and that of ****** is preferred. Heating is performed for a short time and 5 seconds - less than 1 minute are especially preferred less than 5 minutes. Since a sludge is formed and corrosion resistance falls while a crystal grain grows, prolonged heating is unsavory.

[0041]500-700 ** of annealing temperature is preferred after cold work, and its 550-640 ** is especially preferred to it. A corrosion-resistant high thing is obtained below 640 **. It is preferred to perform this heating in Ar or a high vacuum. A degree of vacuum has 10^{-4} - preferred 10^{-5}Torr, and is good for an oxide film not to make it form in an alloy surface substantially, but for the surface to have colorless metallic luster with annealing. As for annealing time, 1 to 5 hours is preferred.

[0042]

[Embodiment of the Invention]

[Example 1] Table 1 shows the chemical entity (% of the weight) of the roller material with which the sliding wear test was presented. It is the chromium carbon-nickel 3 element-system alloy into which the amount of carbide was changed with A1 - A5 carbon content. Those with a nickel alloy which B1 - B5 added aluminum and changed the hardness of the substrate part with the amount (nickel$_3$aluminum) of gamma', and C1-C3 change a chromium amount. D1-D4 add molybdenum, niobium, and titanium to A3. R1 is the cobalt base alloy used as comparison material. The alloy in connection with this invention except a cobalt base alloy was used as the raw material of a near net shape by precision casting, and ingot (5 kg) raw material by vacuum melting, and was processed into a roller the outer diameter of 17 mm, 5.5 mm in inside diameter, and 7.5 mm in width from these raw materials.

[0043]

[Table 1]

	C	Si	Mn	Ni	Cr	Mo	Al	Nb	Co	W	その他	Cr−8C
A1	1.0	0.3	0.3	Bal	30.0	−	−	−	−	−		22
A2	1.5	0.3	0.3	Bal	30.0	−	−	−	−	−		18
A3	2.0	0.3	0.3	Bal	30.0	−	−	−	−	−		14
A4	2.4	0.3	0.3	Bal	30.0	−	−	−	−	−		10.8
A5	2.8	0.3	0.3	Bal	30.0	−	−	−	−	−		7.6
B1	2.0	0.3	0.3	Bal	30.0	−	1.0	−	−	−		14
B2	2.0	0.3	0.3	Bal	30.0	−	2.5	−	−	−		14
B3	2.0	0.3	0.3	Bal	30.0	−	4.0	−	−	−		14
B4	2.0	0.3	0.3	Bal	30.0	−	6.0	−	−	−		14
C1	2.0	0.3	0.3	Bal	18.0	−	−	−	−	−		2
C2	2.0	0.3	0.3	Bal	25.0	−	−	−	−	−		9
C3	2.0	0.3	0.3	Bal	35.0	−	−	−	−	−		19
C4	2.0	0.3	0.3	Bal	40.0	−	−	−	−	−		24
D1	2.0	0.3	0.3	Bal	30.0	3.0	−	−	−	−		14
D2	2.0	0.3	0.3	Bal	30.0	−	−	0.5	−	−		14
D3	2.0	0.3	0.3	Bal	30.0	−	−	1.5	−	−		14
D4	2.0	0.3	0.3	Bal	30.0	−	−	−	−	−	Ti0.5	14
D5	2.0	0.3	0.3	Bal	30.0	−	−	−	−	−	Ti1.5	14
D6	2.0	0.3	0.3	Bal	30.0				−	3.0		14
R1	2.5	1.0	1.0	0.5	32.0	0.1		−	−	Bal	Fe2.9	12

The chemical entity of the pin material which turns into a mating material in a sliding wear test is shown in Table 2. it is the pin material of an iron group alloy which examined by P's1 combining with the roller of this invention of A1−D4, and coming out, and P2 is a pin of the cobalt base alloy which examined by combining with the roller material of the cobalt base alloy of R1, and coming out. After P1 made cylindrical the ingot produced by the dissolution with hot forging and performed cold work 30% further, it was taken as the phi5.5mm pin by machining.

[0044]

[Table 2]

	C	Si	Mn	Fe	Ni	Co	Cr	V	W
P1	0.75	3.5	8.1	Bal	8.3	−	17.1	3.0	−
R2	0.1	0.2	1.5	2.1	10.3	Bal	20.2	−	15.1

Table 3 shows a wear test result, a Charpy impact test result, the corrosion test result in the inside of high temperature hot water and the hardness of a substrate part, and the surface ratio of Cr carbide about the roller material by precision casting. The wear test inserted the pin in the roller, equipped the testing machine with it, pushed the roller against the solid of revolution mad from stainless steel (SUS316L) by 10 kg of load via the pin, and was done. The test atmosphere was carried out the inside of the 288 ** high temperature hot water which imitated real furnace conditions, was performed with roller peripheral velocity 0.03 m/s and the mileage of 10 km, and made abrasion loss the amount of weight loss per km. The Charpy impact test was done using the notch−less specimen of 10 mm squares. The corrosion test calculated the amount of weight loss when it was neglected for 2000 hours in 288 **, 0.2 ppm of dissolved oxygen, and the elevated−temperature pure water of pH 7.2.

[0045]

[Table 3]

No.	摩耗減量(mg/km)		シャルピー衝撃値 (kgm/cm²)	腐食減量 (mg/cm²)	基質部の硬さ (Hv)	Cr炭化物の面積比 (%)	2次炭化物の面積比 (%)	基地のCr量(wt%)
	ローラ	ピン						
A1	5.3	2.8	1.95	1.1	226	12.5	0	22.8
A2	3.0	2.0	1.05	1.1	239	17.7	0	18.6
A3	1.7	2.1	0.85	1.2	251	22.5	0	15.3
A4	1.6	2.5	0.71	1.5	256	26.8	0	12.0
A5	1.8	6.3	0.55	1.9	260	30.3	0	8.9
B1	1.6	2.2	0.52	1.1	266	22.7	0	14.8
B2	2.1	2.8	0.46	1.1	303	22.5	0	15.0
B3	4.3	3.8	0.35	0.8	353	22.8	0	15.1
B4	6.5	5.5	0.20	0.9	390	22.8	0	15.5
C1	2.5	2.7	1.10	3.6	239	19.5	0	3.1
C2	1.7	2.2	0.95	1.8	242	20.3	0	10.6
C3	1.6	2.1	0.81	1.2	255	23.2	0	19.8
C4	2.0	2.4	0.73	1.0	261	24.2	0	24.7
D1	1.7	2.2	0.62	0.7	301	21.5	1.3	18.2
D2	2.1	3.0	0.55	0.8	295	22.0	0.8	15.0
D3	3.9	3.5	0.36	0.8	378	20.1	2.5	18.1
D4	1.9	2.7	0.59	0.8	365	22.3	1.0	16.5
D5	3.6	2.9	0.37	0.9	375	20.7	2.8	16.2
D6	1.8	2.2	0.60	1.1	305	22.2	1.5	15.8
R1	4.2	2.5	0.80	1.8	257	−	−	

In a chromium carbon−nickel ternary alloy, abrasion loss decreases with increase of the carbon content of chromium carbide, i.e., the amount, and abrasion loss becomes small from a Co base alloy by surface ratio at not less than (not less than 1.5% of carbon content) 10%, and it shows good abrasion resistance to the real target which changed the carbon content of A1 − A5. However, if it exceeds 25% (2.5% of carbon content), the abrasion loss of a mating material (pin) will become remarkable. It is ** carrying out of the good abrasion characteristic in the carbon content 1.5 − 2.5wt% (10 to 25% of surface ratio of the amount of chromium carbide) of the range.

[0046]Fix B1 − the amount of chromium carbide of B4, and if the hardness of a nickel base place exceeds Hv300 from the wear test result at the time of changing the hardness of a nickel base place in the amount of gamma', and the amount of secondary carbide, abrasion loss will increase. If set to 350 or more Hv(s), since abrasion loss will become large and an impact resistance value will fall remarkably rather than a Co base alloy, it turns out that it is necessary to set hardness of a base to 350 or less Hv.

[0047]About chromium, the corrosion weight loss in the inside of high temperature hot water becomes larger than a Co base alloy at 12+8xC % or less from the result of C1−C4, and if it exceeds 25+8xC %, the effect over corrosion resistance will be saturated and the fall of an impact resistance value will become remarkable.

[0048]The result of D1−D4 shows that addition of 1 − 5wt% of molybdenum has an effect in corrosion−resistant improvement, without spoiling abrasion resistance. 1 − 5wt% of tungsten also has an effect in wear−resistant improvement, without spoiling corrosion resistance. It is 0.5wt% to a pan. The following niobium or titanium is also effective in corrosion−resistant improvement in high temperature hot water. However, these elements are secondary carbide formation elements, if it becomes more than the above−mentioned quantity, the hardness of a base will be set to 350 or more Hv(s), and abrasion loss will increase on the contrary.

[0049]Drawing 2 shows the typical organization (A3) of this invention. The portion which looks black is chromium carbide.

[0050]Drawing 3 shows the roller wear section of the alloy (A3) of this invention. The chromium carbide broken finely is embedded into the plastic flow layer near the surface.

[0051]Drawing 4 is a diagram showing the relation between corrosion weight loss and the amount of Cr(s) of a base. By raising the amount of Cr(s) of a base, as shown in a figure shows that corrosion is controlled. Corrosion resistance improves notably by making the amount of Cr(s) of a base into not less than 10% especially. The higher corrosion resistance at not less than 12% is acquired.

[0052]Drawing 5 is a diagram showing the relation between a roller, and the abrasion loss of a pin and the amount of C. As shown in a figure, as for a roller and a pin, abrasion loss has few amounts of C notably at 1.5 to 2.5%.

[0053]Drawing 6 is a diagram showing the relation between the abrasion loss of a roller, and the

area rate of Cr carbide. Abrasion loss can be carried out in km and about 4mg /or less by making the area rate of Cr carbide into not less than 10%, as shown in a figure. In particular, the thing of smaller abrasion loss is obtained at not less than 20%.

[0054]Drawing 7 and drawing 8 are the diagrams showing the relation between the abrasion loss of a roller and a pin, and the hardness of a base. As shown in drawing 7, the hardness is raised in a Cr-nickel-C system alloy by the amount of Cr carbide, and, as a result, the abrasion loss of a roller lowers the abrasion loss of a roller. Abrasion loss can be lessened by making hardness of a base or more into 240 especially more preferably 230 or more by Hv. While the thing of B series of the alloy containing aluminum raises the content of aluminum, abrasion loss increases remarkably by the increase of hardness, especially Hv 350 or more. Abrasion loss of the alloy of D3 and D5 which contain Nb and Ti 1.5% respectively increases notably in Hv 380 or more. Although, as for D1 and D6 containing Mo and W, the hardness of a base becomes high, abrasion loss does not change but has high abrasion resistance.

[0055]As shown in drawing 8, by a Cr-nickel-C system, as for the abrasion loss of a pin, the hardness (Hv) of a base increases rapidly 260 or more. In the hardness (Hv) of a base, in B series containing aluminum, abrasion loss increases or more by 360. In Mo and W, about 400 do not become big abrasion loss in 400, and Ti and Nb by Hv.

[0056]Drawing 9 is a diagram showing the relation between the abrasion loss of a roller and a pin, and Al quantity. By making aluminum contain, the hardness of a base is raised rapidly and abrasion resistance falls with a roller and a pin conversely. High wear arises especially at not less than 4%.

[0057]Drawing 10 is a diagram showing the relation between a roller and the abrasion loss of a pin and Mo, Nb, Ti, and the amount of W. As shown in a figure, since abrasion loss does not increase to about 5%, Mo and W are effective in corrosion-resistant improvement. Since Ti and Nb increase abrasion loss rapidly especially in a roller, it is preferred to carry out both Ti and the amount of Nb(s) the following 1.5%.

[Example 2] Drawing 11 is a fragmentary sectional view of a boiling water reactor core.

[0058]It is operated by the steam temperature of 286 **, and steam pressure 70.7atg, and 500 and 800 or 1100 MW power generation are possible for this nuclear reactor as a generation output. Each name is as follows. A reactor core, The neutron source pipe 51, the core support plate 52, the neutron instrumentation detection tube 53, the control rod 54, the reactor core shroud 55, the top guide 56, the fuel assembly 57, the upper mirror spray nozzle 58, the vent nozzle 59, the pressure vessel lid 60, the flange 61, the nozzle 62 for measurement, the steam separator 63, The shroud head 64, the water supply inlet nozzle 65, the jet pump 66, the steam drying machine 68, the vapor outlet nozzle 69, the feed water sparger 70, the nozzle 71 for core sprays, the lower reactor core lattice 72, the recirculated water entrance nozzle 73, the baffle plate 74, and the control rod guide tube 75 are provided.

[0059]The above-mentioned top guide 56 has the rim trunk 21, the flange 22, and the shot plate 35, and the rolled stock of SUS316 steel polycrystal is used for these. Immobilization is not carried out mutually only by the shot plate 35 crossing mutually. Similarly SUS316 steel polycrystal rolled stock is used, it is manufactured by the rolled plate of one sheet, the hole to which fuel dummy support is attached is provided, and the core support plate 52 is fixed to a furnace container in a circumference surface. Therefore, all are structures without a soldering part in the central part which receives neutron irradiation.

[0060]Drawing 1 is a sectional view of the control rod drive mechanism by an electric motor in which a slight movement drive is possible. The pin of P1 shown in the roller and Table 2 of sample A3 of Table 1 was manufactured like Example 1, it equipped with 32 sets, and the load drive examination corresponding in 40 was done by the circulation among high temperature hot water which imitated the real furnace. As a result, the dimensional change by wear is small and roller and a pin satisfy a design basis enough. Breakage by the impact load at the time of a scrum drive was not seen at all, either.

[0061]The control rod drive mechanism in this example drives the control rod 1 up and down vi the hollow piston 4 through the screw 9 for a piston drive which rotates by the motor 3 by the driving piston 7, and is connected to the reactor pressure vessel 2 by welding. The control rod

is driven in the control rod guide tube 5. By inserting water in an emergency from the water insertion piping 8, the water pressure driving piston 10 lifts the control rod 1 quickly up, and is separated in the driving piston 7. As for the portion which touches especially high temperature hot water, SUS316L is used. The control rod 1 has structure which falls by self-weight.
[0062]The roller and pin in this example are formed so that a hollow piston can move smoothly between each position hollow piston 4 of A-H illustrated, and the various tubes formed in the housing 6. A is a buffer part, and there are two places up and down and it is respectively provided at intervals of every 4 times [90]. B — a stop piston part and C — provide the ball screw upper part and E in a latch supporter, F is provided in the latch lateral surface, and, as for G, a spindle beef fat part and every four D each are provided in two each in a hollow piston / ball nut part. H is a middle flange and is provided six pieces on the circumference. The roller of each portion and the shape of a pin are as follows.
[0063]Drawing 12 is the sectional view which inserted the pin 17 in the roller 16 in the A section, and, as for the pin 17, rotation is restrained by the presser-foot pin 18. The pin 17 has a diameter of a three-stage. It is heavy-gage with a pin part, and the roller 16 has become thin meat a little in the peripheral face.
[0064]Drawing 13 is the sectional view which inserted the pin 17 in the egg-shaped roller 16 of similarity of the section [in the C section / the lateral part and drawing 14] and establishing in the inner part. The roller and pin of the structure as drawing 6 where the D section is the same are formed. The pin 17 is a large diameter in the head, and the opposite side side of a roller part and a head has a straight structure.
[0065]Drawing 15 is the roller 16 and the pin 17, and the former is a ball nut roller pin. [in / in the G section and drawing 16 / the H section] The head of the pin 17 is a major diameter from the roller part a little with the cone form about the tip part.
[0066]Drawing 17 is an assembly plot plan of the control rod 1 driven with the control rod drive mechanism 11, a fuel assembly (A), (B), the central fuel dummy support 14, and the core support plate 12. Drawing 17 (A) is a fuel assembly which does not have a handle, and is arranged at the b section of drawing 17 (C). Similarly, (B) has a handle and is arranged at a of drawing 17 (C). It is fixed in contact with the core support plate 12, and the fuel dummy support 14 supports a fue assembly. The control rod 1 used for a sheath and B_4C, or Hf tube the alloy of No.5 shown in Table 1 in this example. B_4C or Hf tube repeated and obtained cold rolling and annealing with the pinger mill, after making the element tube by between heat. After the sheath repeated cold rolling and annealing and used them as sheet metal, it was obtained by welding.
[0067]Drawing 18 is a sectional view of the fuel assembly for boiling-water reactors concerning this invention.
[0068]two or more steps of spacers 27 which hold many fuel rods 21 and them at the predetermined intervals mutually as a BWR fuel assembly is shown in a figure — further, It comprises the handle 31 for conveying the top stay plate 25 and the bottom tie plate 26 holding the both ends of the fuel rod 21 with which the fuel pellet entered them in the channel box 24 o a storage shin rectangular pipe, and the fuel cladding tube, the water rod 22 arranged in the central part of a spacer, and the whole. When manufacturing these fuel assemblies, it is assembled through the usual process.
[0069]The channel box 24 stores the fuel rod and the water rod 22 which were unified by the spacer 27 inside, and where the top stay plate 25 and the bottom tie plate 26 are fixed with the water rod 22, it is used. The channel box 24 presents 4 halved m in length, and the rectangular pipe shape where thickness joined the shape board processing material of three sorts of 80,100,120-mil KO by plasma arc welding. This member rectifies the high temperature hot water which flows between the steam and fuel rod by which it was generated on the fuel rod surface a the time of a plant operation, and serves to lead to the upper part compulsorily. Since an intern pressure is slightly higher than the exterior, after the stress which extends an rectangular pipe outside has acted, long term use is carried out.
[0070]Three fuel assemblies in this invention are arranged symmetrically [the water rod 22] with the central part of the spacer 27, All are fixed to a stay plate with a screw at both ends,

and screw stop immobilization of the channel box 24 is carried out at the top stay plate 25, and the fuel assembly has a structure carriable by one by the handle 31. As for the fuel rod, in this example, immobilization is not carried out to a stay plate.
[0071]Heat treatment is performed as follows and, in the orientation rate (Fl) of 0.25 to 0.6, and a longitudinal direction, the orientation rate (Ft) of 0.25 to 0.4 and the cross direction sets [the orientation rate (Fr value) of the <0001> crystal orientation of a board thickness direction] a channel box to 0.25-0.4. It is preferred to be preferably referred to as Fr 0.25 to 0.5, Fl 0.25 to 0.36, and Ft 0.25-0.36. By carrying out orientation in this way by heat treatment, betaZr crystal grain diameter is set to 50-300 micrometers (preferably 100-200 micrometers) on an average, exposure elongation is prevented remarkably, as a result, a bend does not arise but interference with a channel box and a control rod is prevented. The thing which this has arranged around 45 or more GWd/t of burnups, or a bend does not arise, and also it is satisfactorily [at all] usable also with 50 or 60 GWd/t. The use which exchanges fuel to conventional burnup 32 GWd/t is also possible.
[0072]The bend by an outermost periphery will be 0.9 mm in one year (burnup 8 GWd/t), in Fr0.6, it is 0.8 mm and especially the thing of Fr0.67 of a conventional material, Fl0.11, and Ft0.22 is 0.15 mm in Fr0.5 0.45 mm and Fr0.4. Therefore, in burnup 45 GWd/t, with the conventional material of Fr0.67, it will not be prevented by the outermost periphery one year and interference of a control rod is not prevented as 4.5 years in the central part. However, in Fr0.6, it will be made an outermost periphery with one year, and is 4.5 in the central part. Interference is prevented in use of a year. At Fr0.5, it will be 1.5 to four years and the central part in an outermost periphery. Interference is prevented by use of a year. Fr0.4 Below, it is 5.5 only at an outermost periphery. Even if it carries out year use, it does not interfere at all.
[0073]a channel box carries out cold bending of the zirconium group alloy plate shown in Table 4 as alloy composition to the shape of KO, and uses it as the shape member of two length:4m KO — these — laser — or plasma arc welding was carried out and it was considered as the rectangular pipe 12. Unevenness of a weld zone is finished flush. This rectangular pipe was quenched by the cooling water sprayed from the nozzle provided heating to the parent phase temperature requirement by high-frequency induction heating, and directly under the high-frequency-induction heating coil. When an rectangular pipe passes from the upper part in a coil to a lower part with constant speed, the whole heat treatment is completed. Cooking temperature is 1100 **, and not less than 980 ** retention time adjusted the feed rate of an rectangular pipe, and the output of the RF generator, as it had been 10 seconds or more. Treatment temperature can be performed by holding 1,000-1,200 ** for 3 to 10 seconds at 1050-1100 ** especially preferably. After the completion of heat treatment, width: 40 mm and a specimen 40 mm in length were cut down, and the F value was measured. Table 5 shows the measurement result. A heat treatment parameter (P) is 1.96. With the screw 3, heat treatment fixed both ends to the pipe 12, and performed the mandrel 18 made from an austenitic stainless steel in it. a table shows — as — the bottom (0002) of six-sided prisms, and the cylindrical surface — a field (1010) — as an F value — both Fr Fl and Ft — about — it is set to one third and becomes the orientation of completely random crystal orientation. betaZr average crystal grain of this thing was about 100 micrometers. After carrying out shaping sandblast treatment and pickling to high dimensional accuracy after performing this heat treatment, and removing a surface oxide film, autoclave processing by a steam is performed.
[0074]
[Table 4]

No.	合金元素					
	Sn	Fe	Cr	Ni	O	Zr
1	1.50	0.21	0.10	—	0.12	bal.
2	1.50	0.15	0.10	0.10	0.12	bal.
3	1.50	0.25	0.10	0.10	0.12	bal.

[0075]
[Table 5]

熱処理	(0001)面			(1010)面		
	Fr	Fl	Ft	Fr	Fl	Ft
1100℃/10s	0.333	0.333	0.334	0.333	0.334	0.333

As other examples of a channel box, to the above-mentioned thick fixed thing, the corner was thicker than the thickness of the side part, and the side part made it what has the longitudinal direction thickness distribution which is thin meat from the lower part in the upper part. Such a fabricating operation is performed after heat treatment. A fabricating operation is masked, and is performed by the chemical etching or machining by the mixed acid aqueous solution of hydrogen fluoride and nitric acid, and concave of the outside surface side is processed and carried out in this example. Such thickness distribution may be made into concave by the inner surface side.

[0076]According to this example, each of each members became usable by no exchanging for 30 years, and also the prospect which can be used by no exchanging by inspection in 40 years was acquired. It is 288 **, nuclear reactor temperature is after 12-month operation, and not less than 85% of an operating ratio will make it into 35% of thermal efficiency 92% especially not less than 90% the 40th [less than] day preferably in less than 50 months per time while the periodic check in 30 days is carried out especially repeatedly preferably.

[0077]Although the case where the above-mentioned explanation was applied to the pin for a guide and roller which are used for the piston of a reactor control rod drive, and a bush was explained, this invention is not limited to this and can be applied also to the parts used in addition to a nuclear reactor.

[0078]

[Effect of the Invention]Since cobalt is not included at all as alloy composition according to this invention, when it is used as the slide member in a control rod drive, or a padding material in a valve, since there is no elution of cobalt to the inside of furnace water of high temperature high pressure, the dose of radioactivity by stimulated-emission-izing can be pressed down low. Since abrasion resistance is superior to Stellite, there are few dimensional changes of the slide member by wear, and smooth rotation of a bearing part is not spoiled by seizure etc. and operation of a reliable nuclear power plant is attained. Since it furthermore excels in corrosion resistance and shock resistance, there is an effect that high reliability is securable also to prolonged operation or the high speed drive in an emergency etc.

DESCRIPTION OF DRAWINGS

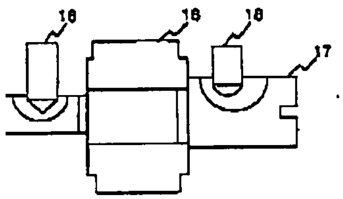
[Brief Description of the Drawings]
[Drawing 1]The sectional view of a control rod drive.

[Drawing 2]The microphotograph in which the metal texture of the section of this invention alloy is shown.
[Drawing 3]The microphotograph in which the metal texture of the section after the wear test of this invention alloy is shown.
[Drawing 4]The diagram showing the relation between corrosion weight loss and the amount of Cr(s) of a base.
[Drawing 5]The diagram showing the relation between abrasion loss and the amount of C.
[Drawing 6]The diagram showing the relation between the abrasion loss of a roller, and the area rate of Cr carbide.
[Drawing 7]The diagram showing the relation between the abrasion loss of a roller, and the hardness of a base.
[Drawing 8]The diagram showing the relation between the abrasion loss of a pin, and the hardness of a base.
[Drawing 9]The diagram showing the relation between abrasion loss and aluminum.
[Drawing 10]The diagram showing the relation between abrasion loss and content.
[Drawing 11]The fragmentary sectional view of a nuclear reactor.
[Drawing 12]The sectional view of a pin and a roller.
[Drawing 13]The sectional view of a pin and a roller.
[Drawing 14]The sectional view of a pin and a roller.
[Drawing 15]The sectional view of a pin and a roller.
[Drawing 16]The sectional view of a pin and a roller.
[Drawing 17]The erection diagram of a control rod drive mechanism, a fuel assembly, and a control rod.
[Drawing 18]The sectional view of a fuel assembly.
[Description of Notations]
1, 54 [— Hollow piston,] — A control rod, 2 — A pressure vessel, 3 — A motor, 4 5 [— Water insertion piping,] — A control rod guide tube, 6 — Housing, 7 — A driving piston, 8 9 [— A core support plate, 13, 21 / — A fuel rod, 14 / — Fuel dummy support, 15 24 / — A channel box, 16 / — A roller, 17 / — A pin, 18 / — A presser-foot pin, 27 / — A spacer, 75 / — Control rod guide tube.] — The screw for a piston drive, 10 — A water pressure driving piston, 11 — A control rod drive mechanism, 12

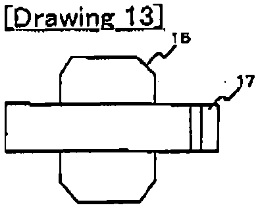
[Translation done.]

DRAWINGS

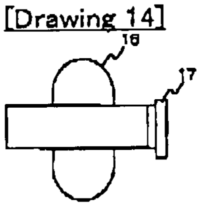
[Drawing 12]



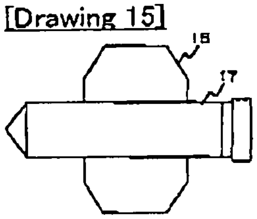
[Drawing 13]



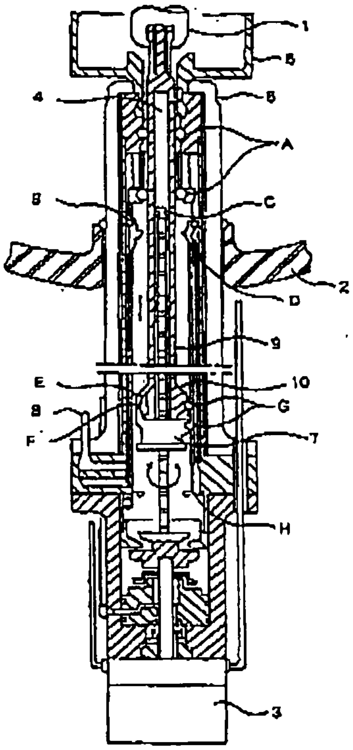
[Drawing 14]



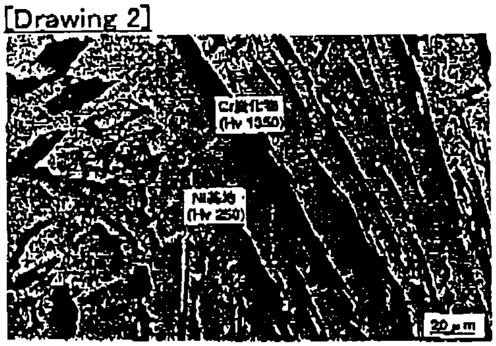
[Drawing 15]



[Drawing 1]

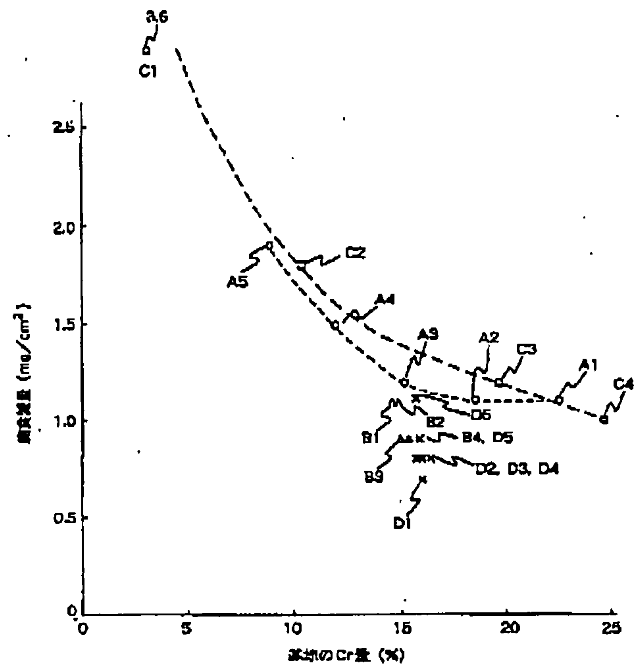


[Drawing 2]

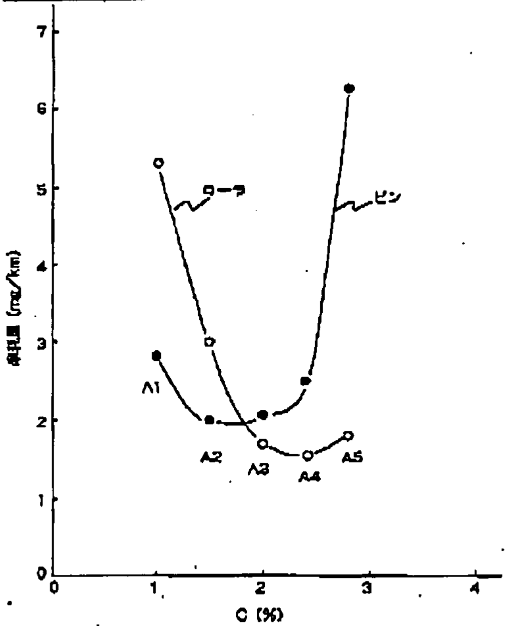


[Drawing 3]

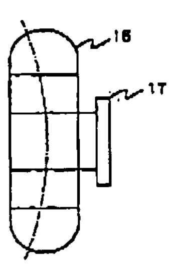
[Drawing 4]



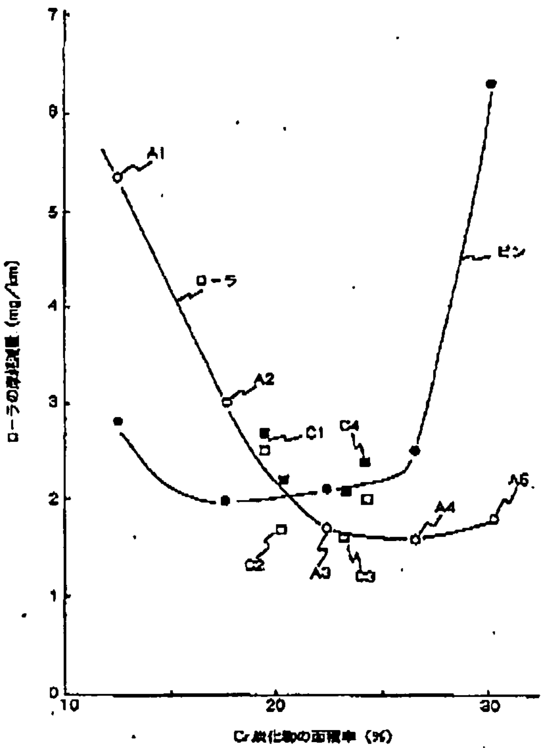
[Drawing 5]



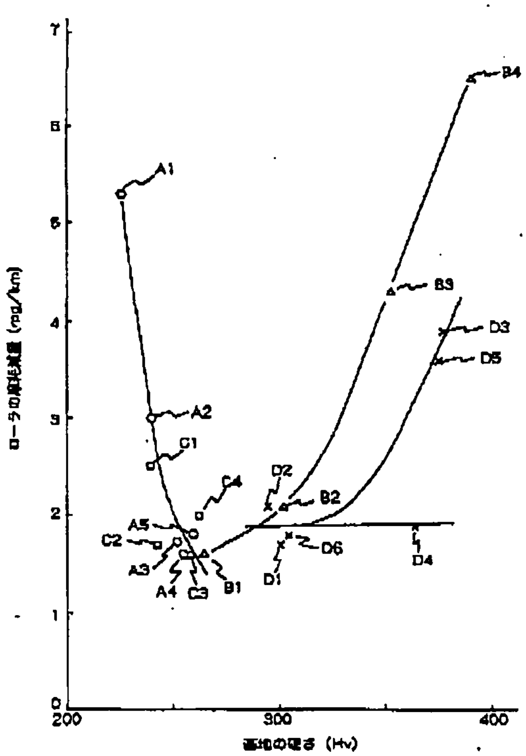
[Drawing 16]



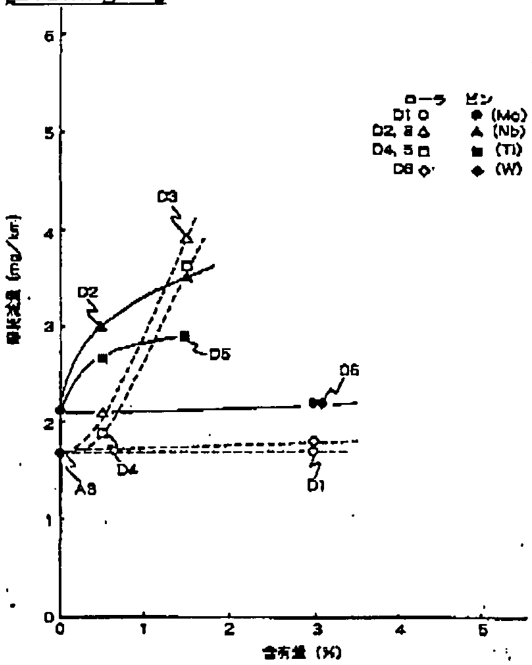
[Drawing 6]



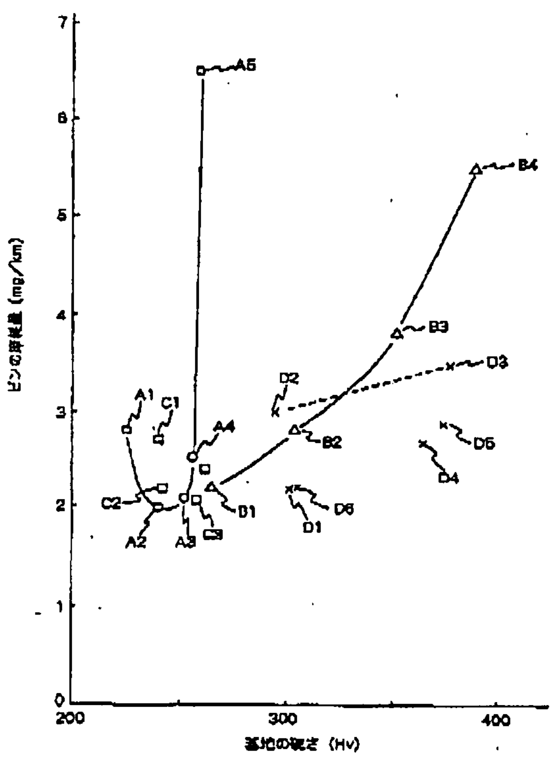
[Drawing 7]



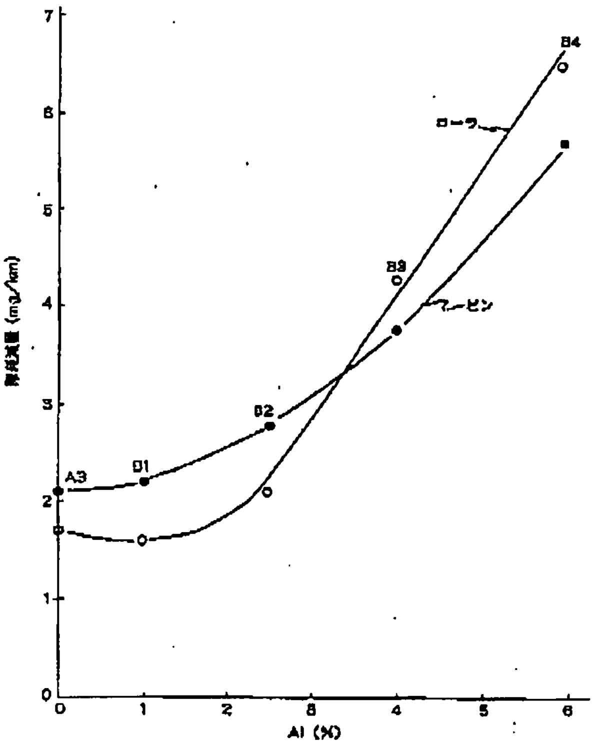
[Drawing 10]



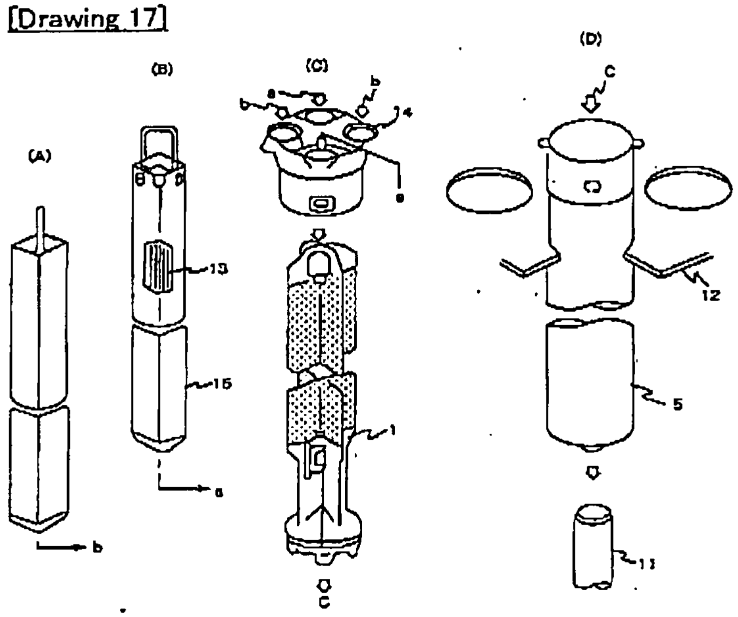
[Drawing 8]



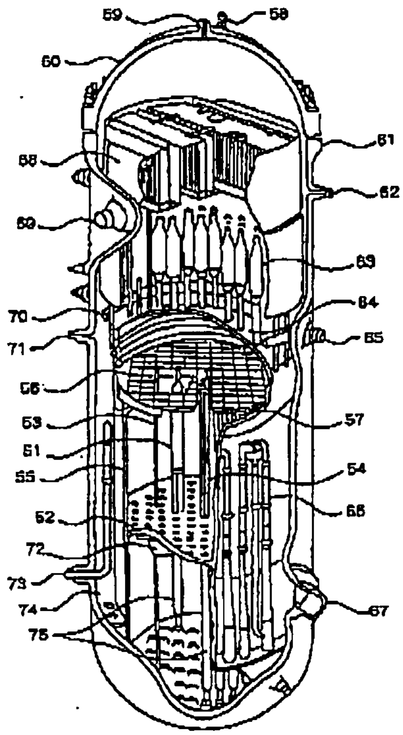
[Drawing 9]



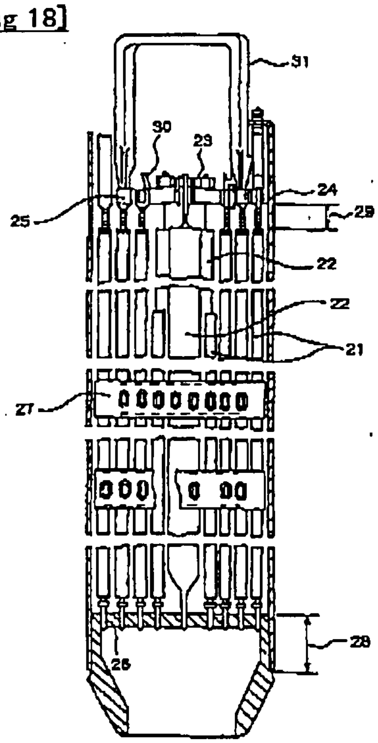
[Drawing 17]



[Drawing 11]



[Drawing 18]



21…燃料棒　22…ウォータロッド　23…ウォータロッド固定ネジ
24…チャンネルボックス　25…上部タイプレート　26…下部タイプレート
27…スペーサ　28…チャンネルボックス嵌合代　29…燃料棒伸び代
30…燃料棒貫通孔　31…ハンドル

[Translation done.]